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Redescription and designation of lectotypes of the North American *Cambarincola okadai* Yamaguchi, 1933 (Annelida: Clitellata: Branchiobdellidae)

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Abstract.—Unlabelled specimens found in the slide collection of Prof. Hideji Yamaguchi were identified as the North American species, *Cambarincola okadai* Yamaguchi, 1933. As no type specimens had been designated, a detailed redescription was made and the specimens were designated as lectotypes for the species. Specimens of this species were named *Triannulata montanus* Goodnight, 1940, then subsequently redescribed and transferred to *Cambarincola montanus.* The latter two names now become junior synonyms of *C. okadai.*

The export and import of crayfishes between countries and continents for commercial reasons has been practiced for many years. Reviews of the various species and countries involved can be found in Holdich & Lowery (1986) with more recent information in Hobbs et al. (1989). Until recently, little attention has been paid to the detrimental effects the exotic species have caused to the native fauna and environment. The best known instances are the widespread introduction of "crayfish plague" into Europe (Söderhäll & Cerenius 1999), and the destruction of paddy field walls (Ackefors & Lindqvist 1994:199, 189). In addition to pathogens, the introduction of crayfishes into new regions is frequently accompanied by non-pathogenic symbionts such as branchiobdellids and temnocephalidans (Gelder 1999). These exotic ectosymbionts often become part of the local fauna and may adopt endemic species as new hosts (Gelder et al. 1999).

The first significant review of branchiobdellids in Eastern Asia was made by Yamaguchi (1934). He described a number of new species but did not specifically designate any type specimens or record their exact collection sites in his publications. A large earthquake in Hokkaido during 1968 destroyed part of Prof. Hideji Yamaguchi's oligochaete collection, so he asked his assistant, Dr. Yukiyoshi Kamihira, Hakodate University, Hokkaido, Japan, to look after the remaining material (Ohtaka, pers. comm.). This action was not widely known, so it was generally assumed that the collection had been completely destroyed. Dr. Akifumi Ohtaka found the slide collection and obtained permission from Dr. Yukiyoshi Kamihira for Dr. Gelder to examine the branchiobdellid slides. At that time, it was realized that the written records supporting the slides had been lost and that none of the slides had been fully labeled.

Four of these unlabeled slides each contained a North American branchiobdellid. Yamaguchi had examined and described a new species of North American branchiobdellid, *Cambarincola okadai* Yamaguchi, 1933, that had been introduced into Japan. Because no type specimens had been designated and no specimens had been reported since the initial examination, *C. okadai*

was considered to be nomen inquirendum by Holt & Opell (1993:253). This study was designed to describe in detail the recently acquired specimens, review the information on *C. okadai,* and attempt to clarify the taxonomic status of the species.

Literature Review

Review of the information on Cambarincola okadai *Yamaguchi, 1933 and North American crayfish in the collection area.*— The description of *C. okadai* was produced "from several specimens . . . attached to . . . crayfish formerly transferred from America into Lake Chuzenji, Nikko", Tochigi Prefecture, collected by Prof. Y. Okada in 1928 (Yamaguchi 1933:191). He also noted (p. 193) that "there has been no report of crayfish from Lake Chuzenji and adjacent districts except those newly transferred from America." It is known that *Pacifastacus leniusculus leniusculus* (Dana, 1852) (or Tankai-zarigani) and *Pacifastacus leniusculus trowbridgii* (Stimpson, 1857) (or Uchida-zarigani) were introduced into Japan from Oregon, U.S.A., five times between October 1926 and July 1930 (Kamita 1970). Specimens of these two subspecies were introduced into Tochigi Prefecture (Kamita 1970: fig. 59 for *P. leniusculus,* and fig. 63 for *P. trowbridgii*), but no records have been found to indicate that these crayfishes were actually released into Lake Chuzenji or exactly when they were brought into the Prefecture.

The description of *C. okadai* by Yamaguchi (1933) stated that the longest specimen was 7 mm in length, but no range of variation was given. The elongate, cylindrical body had a distinct head with the peristomium supporting "four distinct digitiform appendages," (dorsal tentacles), and slightly bilobed ventral lip. No lateral lobes were noted in the text but two small lateral lobes can be seen in his fig. 1. The jaws were illustrated in detail in his fig. 2 showing them to be similar in size and triangular in shape with a large median tooth and two pairs of small teeth. The width of the jaw base was calculated from his fig. 2 to be 130 μm wide. The single anterior nephropore, "abundant male reproductive cells [spermatozoa]" in segments 5 and 6, tubular spermatheca, and the "spermatic vesicle [glandular atrium] is bifid, having the accessory sperm tube [prostate gland]" are all valuable taxonomic characters that together suggested a member of the North American genus *Cambarincola.* The origin of the prostate gland on the glandular atrium, presence of a protrusible penis together with other details and proportion of the male reproductive system are critical for identifying and defining a species of *Cambarincola.* Unfortunately, most of these details were not included in Yamaguchi's description. However, based on the information available to Prof. Yamaguchi this was a new species and clearly separable from the sister species of *Cambarincola philadelphicus* (Leidy, 1851) and *Cambarincola chirocephalus* Ellis, 1919. For completeness it should be noted that a year earlier Yamaguchi (1932:456) eluded to examining "a section made from *Cambarincola* sp." and continued in a footnote to say, "The species was obtained from crayfishes transferred from North America in a Japanese lake and is probably referable to *C. philadelphicus.*"

Reference to *C. okadai* after the type description has consisted of Yamaguchi (1934) repeating the essential information in the type description. However, in a shortened review of the latter paper written in Japanese, Yamaguchi (1935) gave *C. okadai* the Japanese name, Yadorimimizu, Goodnight (1940) in his review of the Branchiobdellidae, quoted the information on *C. okadai* from Yamaguchi (1933), classified the species as "sp. dub." and added, "appears to the writer to be identical with *Cambarincola philadelphica,* as it differs from it only in the dentation of the lower jaw (p.43)." The species was mentioned incidentally by Hoffman (1963:276), Holt (1986:699), Timm (1991:329), then Holt &

Opell (1993) gave it the status of nomen inquirendum which was accepted in the checklist of branchiobdellidans (Gelder 1996).

Possible branchiobdellid species on North American signal crayfish introduced into Japan.—A review of the currently described branchiobdellids with dorsal lip appendages found on *P. leniusculus* subspecies in the Pacific Ocean drainage region of North America resulted in only two species, *Sathodrilus lobatus* Holt, 1977 and *Cambarincola montanus* (Goodnight, 1940). *Sathodrilus lobatus* is about 2.5 mm long, with six lobes on the dorsal lip, a dental formula of 5/4 (Holt 1977), and is not similar to *C. okadai.* The second species, *C. montanus,* was originally named *Triannulata montanus* Goodnight, 1940, and its type description contained a few errors. These were corrected in an emended description by Holt (1974), resulting in the species being transferred to the *Cambarincola* as a "new comb."; the holotype number in his paper should read, USNM 20566. This description (Holt 1974:67) stated a body length of about 5.8 mm, triannulate appearance of segments, peristomium with four dorsal lip tentacles, two pairs of lateral lobes and a ventral lip of four lobes; no oral papillae were detectable. Holt (1974:68) reported, "The usual dental formula is 1/1 with prominent blunt teeth. Younger, though large, specimens from the Kalami River, the type-locality, have a dental formula of 5/5, but the lateral teeth are obscure and probably wear away with age." An examination of about 10 adult specimens of *C. montanus* collected from southern British Columbia, Canada, all showed the large median tooth and two pairs of small, lateral teeth (Gelder & Hall 1990:2355). Given the available information, the 5/5 dental formula appears to be the representative form of the species. The spermatheca and male reproductive system were described in detail and drawn by Holt (1974:68) who also noted that the prostate gland was formed from vacuolated or "differentiated" gland cells. He reported the distribution of *C. montanus* to extend from Santa Barbara County, California, to northern Washington State along the Coastal and Cascade Ranges on *Pacifastacus leniusculus klamathensis* (Stimpson, 1857), *P. l. leniusculus,* and *P. l. trowbridgii.*

Description of branchiobdellid specimens from Yamaguchi's collection

Cambarincola okadai Yamaguchi, 1933 (Japanese name: Yadorimimizu) Fig. 1A–F

Material examined.—Four mounted, unnamed specimens from (box.slide numbers: 2.4, 2.9, 2.10, 2.20) the oligochaete slide collection of Prof. H. Yamaguchi are almost certainly all or part of the syntype material; however, only Yamaguchi's ledgers can confirm this. Three of these specimens have been deposited in the Division of Biological Science, Graduate School of Science, Hokkaido University, Japan (ZIHU): slide 2.20 is designated the lectotype (ZIHU-1347) and slides 2.4 and 2.10 become paralectotypes (ZIHU-1348, ZIHU-1349), with the fourth slide—2.9—placed in the National Museum of Natural History, Smithsonian Institution, Washington D.C., U.S.A. (USNM) as the third paralectotype (USNM 186575).

Brief description.—Body rod-shaped (Fig. 1A), ranging in length from 3.4 to 4.7 mm (average length 3.9 mm) with dorsal ridges and supernumerary muscles absent. The segments are not pronounced and each appears to be divided into three annuli. The presence of an anterior nephridial pore could not be verified in these specimens, but it is expected to open medially on the dorsal surface of segment 3. There are paired, lateral groups of epidermal glands on segments 8 and 9. The peristomium has a dorsal lip with four distinct lobes (l) (or short tentacles), two pairs of lateral lobes, and a ventral lip (v) consisting of a pair of short lobes laterally and a central portion with a slight median incision (Fig. 1B).

There are 16 oral papillae present. The jaws are similar in size and triangular in shape with a large median tooth and 4 small lateral teeth on the anterior facing margin; dental formula 2-1-2/2-1-2. The ventral jaw is sometimes slightly smaller than the dorsal, with the base width ranging from 95 to 130 μm (Fig. 1C, D). The glandular atrium is about one third the diameter of the segment, tubular, folded, and with each vas deferens entering an ental lobe. The prostate gland arises at the meeting point of the glandular and muscular atria, and is slightly longer and wider than the glandular atrium (Fig. 1E). The prostate is lined with columnar gland cells which contain neither granular nor vacuolar secretions. The muscular atrium is short, about half the length of the glandular atrium, and leads into a protrusible penis (p) located in the ental portion of the pyriform bursa (b) (Fig. 1F). The length of the spermatheca is about half the diameter of the segment. The ental half consists of a tubular to sub-spherical bulb (sb) connected to a narrow duct (sd) that ends at the epidermis in a small papilla (Fig. 1E).

Variations.—The jaws are virtually the same size. The ventral jaw is usually slightly smaller than the dorsal, and the median region carrying the teeth of both is of constant size. However, the base of the jaws does vary in width; in the specimens examined dorsal jaws range from 95 μm (Fig. 1C) to 130 μm (Fig. 1D).

Comparison of the morphology between the description of C. okadai *and the unlabeled specimens.*—A comparison of character states of *C. okadai* reported by Yamaguchi (1933) with those observed from the four newly found, unlabeled slide specimens show many to be the same: the shape of the body; segments divided into three annuli; the peristomial appendages having the same arrangement, size and number; identical jaws in shape and dimensions; an unbranched spermatheca in segment 5; a pair of testes in both segments 5 and 6; and the "spermatic vesicle is bifid, having the accessory sperm tube" [prostate gland] in segment 6.

One character, body length, appears to differ as only a maximum body length of 7 mm was reported by Yamaguchi (1933). However, the specimen in his fig. 1 was calculated to have a length of about 5 mm and this compares well with the longest examined specimen being 4.7 mm. Therefore, the report of a 7 mm long body most probably resulted from the specimen reacting in a slightly different way to the preparation process. Another character dimension in close agreement is the width of the base of the jaws. In two of the type slides the aspect of the jaws has the same appearance as those in Yamaguchi's fig. 2. The measured distance (Fig. 1D) and the calculated distance in his fig. 2 result in both bases being 130 μm wide.

Comparison of the morphology between C. okadai *and* C. montanus.—The dental formula usually provides the most readily visible character for identification. The reported range in dental formula spans 7/5 (Goodnight 1940) to 1/1 (Holt 1974), however, a 5/5 arrangement was reported by both Holt (1974) and Gelder & Hall (1990), and appears to be the usual configuration. The prostate gland consists of secretory cells with either granular or vacuolar contents. Many fixatives, including that used by Holt (1986:679), preserve these cytological character states so that the state can be included in the species description of a *Cambarincola* species. In *C. montanus* the "cells . . . are highly vacuolated, that is, differentiated" (Holt 1974:68). This character is not always reliable in a specimen because some fixation procedures do not preserve the form of the secretions (Gelder, unpubl. data). The fixatives used on specimens of *C. montanus* collected from British Columbia, Canada (Gelder & Hall 1990), and on *C. okadai* are unknown, but both procedures turned the respective specimens brown indicating a similar postfixation effect. The contents of the prostate gland cells in both of these groups was unclear. There-

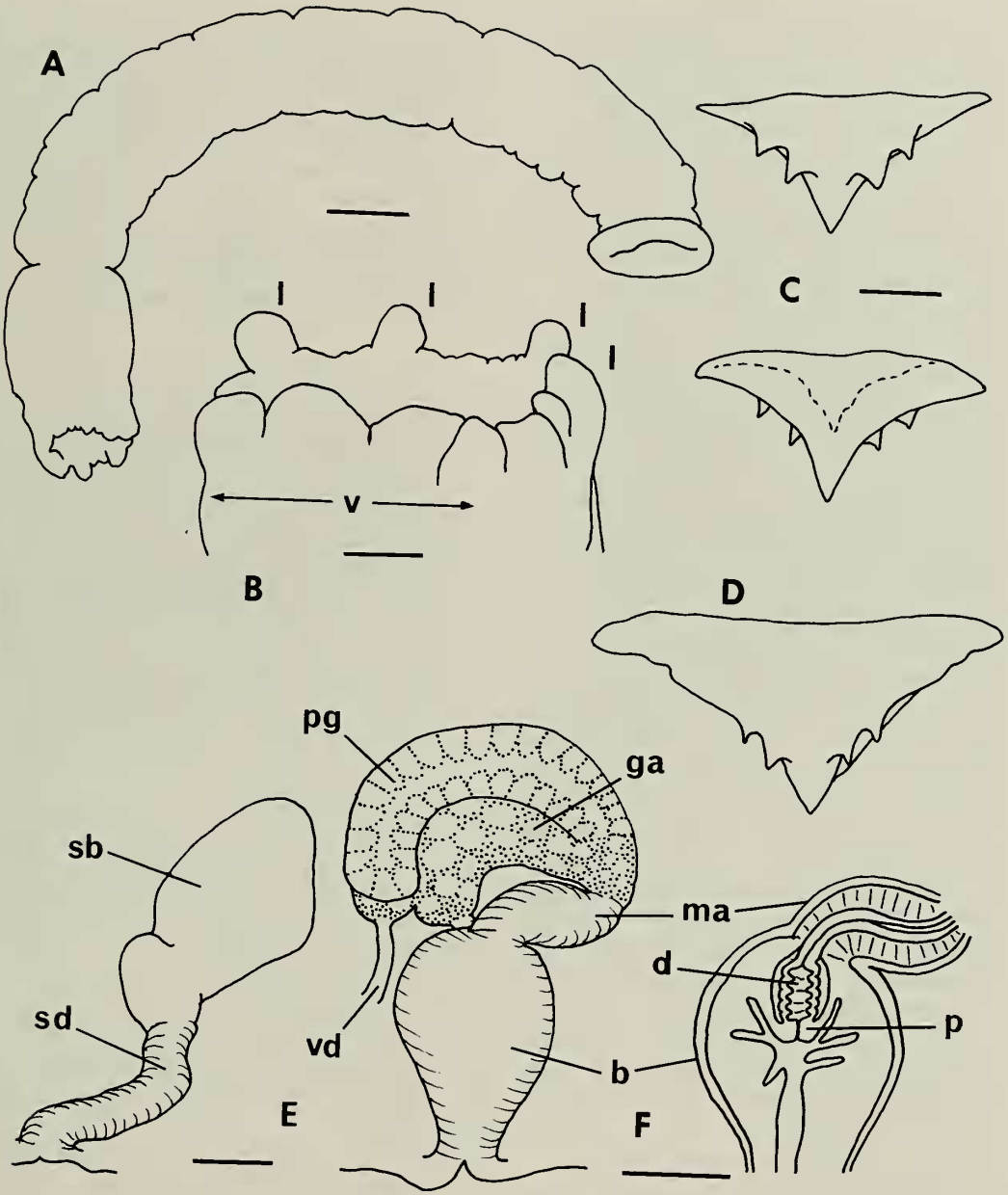

Fig. 1. *Cambarincola okadai:* A, Twisted oblique lateral view of the lectotype, scale bar = 0.1 mm; B, ventral view of the peristomium of a paralectotype, scale bar = 50 μm; C, dorsal (above) and ventral (below) jaws of a paralectotype from the ventral aspect, scale bar = 25 μm; D, dorsal jaw of another paralectotype from the ventral aspect, same scale as C; E, segments 5 and 6 with spermatheca (left) and male genitalia (right) respectively from a paralectotype drawn from a lateral aspect, scale bar = 50 μm. F, optical section of the muscular atrium and penis in the dorsal portion of the bursa, scale bar = 50 μm. Abbreviations: b, bursa; d, deferent duct; ga, glandular atrium; l, lobes on dorsal lip of peristomium; ma, muscular atrium; p, penis; pg, prostate gland; sb, spermathecal bulb; sd, spermathecal duct; v, ventral lip; vd, vas deferens.

fore, the vacuolar contents reported by Holt may not be significantly different from the cells reported in the Canadian and Japanese specimens. A key character for placing a species in the *Cambarincola* is the presence of a "protrusible" penis. The deferent duct in *C. okadai* is surrounded by the circular muscles of the muscular atrium and then passes into the dorsal portion of the bursa before ending in the penis (p) (Fig. 1F). The last portion of the deferent duct wall is greatly compressed into a concertina form (d) when the penis is retracted into the bursa. The penis in both *C. okadai* and reference specimens of *C. montanus* was found to be identical. The proportions of the spermatheca vary due to its position in the segment, degree of compression and presence or absence of spermatozoa in the bulb. Taking these factors into account, there are no significant differences between the spermathecae of the specimens examined.

Taxonomic conclusions.—The four specimens from the Yamaguchi collection have been identified as *C. okadai* based on their close morphological similarity to the type description. Current studies on crayfishes introduced into Japan require a complete species description of *C. okadai* to be available for comparison with newly collected branchiobdellids from imported crayfishes. Therefore, one of the four specimens was designated the lectotype and the three others as paralectotypes according to Article 74 (I.C.Z.N. 1999). In addition, *C. montanus* now becomes a junior synonym of *C. okadai* due to Article 23, Principle of Priority (I.C.Z.N. 1999).

Reported distribution.—The range of *C. okadai* extends from Santa Barbara County, California, to northern Washington State along the Coastal and Cascade Ranges in the U.S.A. (Holt 1974:68), British Columbia, Canada (Gelder & Hall 1990:2354), and Lake Chuzenji, Tochigi Prefecture, Japan (Yamaguchi 1933).

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